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OSUS ROOT ROT MORTALITY IN EASTERN WHITE PINE IN THE SOUTHERN APPALACHIANS

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Cover:

Fomes annosus sporophore at base of dead white pine. Sporophores were found at the base and on lateral roots of standing dead, windthrown, and living white pines.

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ANNOSUS ROOT ROT MORTALITY IN EASTERN WHITE PINE IN THE SOUTHERN APPALACHIANS

By

Charles E. Cordell

ABSTRACT

Plots were established in seven eastern white pine plantations and one natural stand in western North Carolina and western Virginia to determine the rate of *Fomes annosus* spread and resulting mortality. During the six-year period, 1964-70, mortality in six plantations thinned between 1957 and 1959 was 3.6 trees (.33 standard cords) per acre per year. During the same time period, mortality in a 43-year-old white pine plantation first thinned in 1947 and in a 66-year-old natural stand first thinned in 1950 was 3.8 trees (.79 standard cords) and 3.3 trees (.74 standard cords) per acre per year, respectively. The results show significant but erratic *F. annosus* mortality patterns in five eastern white pine plantations and one natural stand in western North Carolina. However, mortality in two western Virginia plantations was comparatively insignificant.

INTRODUCTION

Annosus root rot, caused by *Fomes annosus* (Fr.) Cke., presently has a widespread geographic and host distribution in the U.S. (Powers and Hodges, 1970). Results of a 1960 *F. annosus* survey conducted by Powers and Boyce (1961) in the southeast showed a widespread distribution of the fungus in thinned slash pine plantations. Although there is considerable literature on this disease, there is still very little information concerning disease rate of spread and, particularly, timber volume losses to specific host species. Driver and Dell (1961) observed 20 percent volume loss over a five-year period in a thinned slash pine plantation in southern Georgia. Results of a permanent spread plot study conducted by Berry (1968) in Missouri showed *F. annosus* caused mortality to be about five trees per acre per year in thinned shortleaf pine plantations. More recently, study

results obtained by Morris (1970) showed maximum volume losses from *F. annosus* to be 0.5 standard cords per acre per year in thinned loblolly pine plantations and natural stands in the Coastal Plain of Virginia.

Annosus root rot was first detected in eastern white pine *(Pinus strobus* L.) plantations on the Biltmore Estate in western North Carolina in 1923 (Hepting and Downs, 1944). Since then, the disease has been found to be widespread in white pine plantations throughout the southern Appalachians. Boyce (1962) reported *F. annosus* damage in 25 geographically well-distributed white pine stands in western North Carolina. Fifty-six percent of the residual trees in one 33-year-old plantation at Busick, N.C. displayed symptoms and/or signs of annosus root rot. Results of a survey conducted on the French Broad Ranger District - Pisgah National Forest in 1965 revealed the presence of the disease in all seven of the white pine plantations examined (Astin and Franklin, 1965). One 20-acre plantation had 14 infection centers ranging in size from one to 14 infected trees. While the above, and considerably more, information is available concerning the occurrence and distribtuion of *F. annosus* in southern Appalachian white pine plantations, there is no information concerning disease rate of spread and volume losses to this species. Therefore, this study was established in 1964 to determine the rate of *F. annosus* spread and resulting mortality within established infection centers in thinned white pine stands in western North Carolina and western Virginia.

METHODS

Five permanent spread plots (one-tenth-acre in size) were established in four white pine plantations in western North Carolina. Three similar plots (.2-acre to .3-acre) were established in two white pine plantations in western Virginia. The criteria used for stand and plot selections were:

1. Only thinned white pine plantations selected.
2. Plantations thinned only once.
3. Minimum of one *F. annosus* infected tree at each plot location.
4. Minimum of ten residual living trees on the plot.
5. Maximum of 50 percent mortality on the plot.

Data recorded for each stand and plot included the following:

1. Stand location, owner and date of plot establishment.
2. Stand data - age, average height of dominant and codominant trees, site index, spacing, basal area per acre, aspect, soil characteristics, previous land use, and thinning history.
3. Individual tree data - crown class (dominant, codominant, intermediate, suppressed) Dbh, condition class

3. (cont.) (living, standing dead, windthrown), and symptom and sign class (*F. annosus* conks present or absent, thin crown, rotted roots and windthrows).

Each plot was marked and mapped to facilitate scheduled periodic remeasurements. All trees on the plots were numbered and tagged. A detailed stem map was drawn of each plot showing the location of each tree on the plot as well as the plot location within each plantation. The three Virginia plots were established in 1964 by Craig Weidensaul, Pathologist, formerly with the Forest Pest Control Office in Harrisonburg, Virginia. Reorganization of the Forest Service in 1966 resulted in relocation of this office and all previous Forest Pest Control responsibilities in Virginia were transferred to the Forest Pest Control Office in Asheville, N.C. Consequently, these plots were added to the plots established in western North Carolina.

Three additional plots, two in a white pine plantation and one in a natural white pine stand were established in western North Carolina to determine the effect of years since thinning and stand origin (planted vs. natural) on *F. annosus* mortality. Cutting has occurred in both stands twice. The plantation was thinned in the winter of 1947-48 and in 1955. The natural stand was thinned in 1950 and the portion surrounding the study plot, but not the plot itself, was clearcut in 1964.

RESULTS

The results of this study are summarized in Tables 1 and 2. Table 1 shows the mortality realized from *F. annosus* on eight study plots in six white pine plantations thinned between 1957 and 1959. Between 1964 and 1970, mortality increased on six of the eight plots. The average number of trees killed per plot during this period was 3.5 trees with a range from 0-7 trees.

F. annosus total mortality on the eight plots was 28 trees (10.3 percent). Expression of the mortality on an annual per acre infection center basis suggests that mortality from *F. annosus* would be approximately 3.6 trees per acre per year in thinned eastern white pine plantations in the southern Appalachians. Converting this data to cubic foot volume loss by use of Table 2, S.E.F.E.S. - U.S.D.A. Research Note No. 162 (Vimmerstedt, 1961) gives 40.1 cubic feet or .33 standard cords per acre per year.

Table 2 shows the mortality realized from *F. annosus* in the Busick, N.C. white pine plantation thinned first in 1947 and the Boone, N.C. white pine

Table 1. Mortality from *Fomes annosus* in six thinned eastern white pine plantations (thinned between 1957 and 1959) in western North Carolina and western Virginia.

Stand Location	Year Thinned	Plot No.	Total Trees on plot	*F. annosus* mortality[1/]					
				1964		1970		Increase	
				Number	Percent	Number	Percent	Number	Percent
Hot Springs, N.C.	1959	1	27	3	11.1	8	29.6	5	18.5
Hot Springs, N.C.	1958	2	20	1	5.0	6	30.0	5	25.0
Murphy, N.C.	1958	3	38	0	.0	6	15.8	6	15.8
Murphy, N.C.	1958	4	58	1	1.7	8	13.8	7	12.1
Highlands, N.C.	1958	5	12	1	8.3	4	33.3	3	24.7
North River, Va.	1957	6	38	11	29.0	11	29.0	0	.0
North River, Va.	1957	7	46	4	8.7	6	13.0	2	4.3
Pedlar River, Va.	1958	8	35	15	42.9	15	42.9	0	.0
Totals	--	8	274	36	13.1	64	23.4	28	10.3

1/ Dead trees (standing or windthrown) with *F. annosus* sporophores and/or typical annosus root rot symptoms.

Table 2. Mortality from *Fomes annosus* in thinned eastern white pine plantation and a natural stand(thinned first 20 or more years ago) in western North Carolina.

Stand Location	Stand Origin	Year first thinned[1/]	Plot. No.	Total trees on plot	*F. annosus* mortality [2/] 1964 Number	1964 Percent	1970 Number	1970 Percent	Increase Number	Increase Percent
Busick, N.C.	Planted	1947	1	38	20	52.6	22	58.0	2	5.4
Busick, N.C.	Planted	1947	2	40	17	42.5	24	60.0	7	17.5
Total	- - -	- -	2	78	37	47.4	46	59.0	9	11.5
Boone, N.C.	Natural	1950	1	13	5	38.5	7	53.8	2	15.3

1/ Cutting has occurred in both stands twice.

2/ Dead trees (standing or windthrown) with *F. annosus* sporophores and/or typical annosus root rot symptoms.

natural stand thinned first in 1950. Between 1964 and 1970, mortality was still occurring on all three plots in both these stands. The average number of trees killed per plot during this period in the plantation was 4.5 trees with two trees killed on one plot and seven on the other. Two trees were killed on the single plot in the natural stand during the same time period. During the past six years, *F. annosus* mortality in the Busick plantation, again expressed on an annual per acre infection center basis, was 3.8 trees or .79 standard cords per acre per year. During the same period, mortality in the Boone natural stand was 3.3 trees or .74 standard cords per acre per year.

DISCUSSION

Both the degree and pattern of mortality from *F. annosus* observed during the past six years in the six white pine plantations thinned between 1957 and 1959 are interesting. These results are comparable to the degree of mortality observed by Berry (1968) in Missouri for shortleaf pine and Morris (1970) in Virginia for loblolly pine. However, the pattern of *F. annosus* mortality observed in the present study differs considerably from the patterns reported by these two workers. As shown in Table 2, considerable mortality was still occurring in both a planted and a natural white pine stand 20 or more years following initial thinning. On one of the plots in the Busick plantation, thinned first in 1947, 17.5 percent of the residual white pines were killed between 1964 and 1970. This represents a volume loss of 5.8 trees or 1.2 standard cords per acre per year. Boyce (1962) reported at least 20 percent mortality from *F. annosus* in this plantation twelve years following thinning and, as previously stated, observed *F. annosus* sporophores or typical root-rot symptoms on 56 percent of the residual living trees. The similar incidence and pattern of mortality observed in the above plantation and in the natural white pine stand at Boone, N.C. is also interesting and is comparable to results recently obtained by Morris (1970) in planted and natural loblolly stands in eastern Virginia. Mortality in the thinned natural white pine stand was only slightly lower than the mortality observed in the thinned plantation (3.3 trees or .74 standard cords per acre per year vs. 3.8 trees or .79 standard cords per acre per year). A point to consider here is the comparison between number of trees killed and actual volume losses in the various stands. The annual number of trees killed on a per acre basis was approximately the same in all three stand categories (planted and first thinned between 1957 and 1959, planted and first thinned 20 or more years ago, and natural and first thinned 20 or more years ago). However, actual volume losses in standard cords on an annual per acre basis was more than doubled in the two latter stand categories. This resulted from the much larger size of the trees killed in the older Busick Plantation and Boone natural stand. Trees killed in these two stands were primarily dominants or codominants and averaged over 12 inches Dbh and 80 foot high whereas

trees killed in the younger stands were primarily intermediate or suppressed and averaged around eight inches Dbh and 55 feet high. There is more cubic foot volume in one 12 inch x 80 foot tree than in three eight inch x 55 foot trees. This points out the desirability of presenting results in several different ways to facilitate making valid and meaningful interpretations. Expression of the present results only in terms of number of trees killed would lead to entirely different and erroneous interpretations.

There is also a major difference in the types of mortality and symptom expression occurring in white pine as compared with loblolly, slash, or shortleaf pine stands. Windthrown root-rotted white pines are very common in affected southern Appalachian white pine stands (Fig. 1) but are relatively rare in southern hard pine stands. Windthrows accounted for over 50 percent of the total mortality observed in the present study. A large portion of these trees were still alive when windthrown. Boyce (1962) also observed considerable windthrown mortality in thinned white pine plantations in western North Carolina, particularly in the Busick Plantation. This points out the probably significant influence of wind on root-rot mortality in shallow-rooted species such as white pine and provides an explanation to the erratic mortality patterns observed in stands of this species. Another consideration in regard to windthrown mortality concerns white pine stands in recreation areas. In 1969, over 40 white pines were windthrown in a recreation area in western North Carolina as a result of *F. annosus* infection coupled with the occurrence of a severe wind storm. Situations such as this could present a safety hazard to recreationists (Fig. 2) along with the aesthetic losses and cleanup expenses involved. Another symptom frequently associated with *F. annosus* infection is trees with thin or sparse crowns (Fig.3). Boyce (1962) also observed this symptom in several white pine stands in western North Carolina.

F. annosus sporophores (cover) were observed at the base and/or on lateral roots of dead trees(both standing and windthrown) in all of the stands exhibiting mortality. Over 70 percent of all the dead trees observed bore sporophores. In addition, sporophores were found on residual living trees in all the stands. However, sporophore production was very erratic. Fruiting bodies would be present on particular living trees during some years and absent on the same trees during others. Therefore, data concerning sporophore production as an indication of infection are not included in the results. Results obtained from an increment core sampling study conducted by Cordell and Stambaugh (1966) on most of these same plots, showed sporophores to be ineffective indicators of *F. annosus* infection in living white pines.

Fig. 1. A windthrown eastern white pine displaying typical root rot symptoms of *F. annosus*. Many of these trees were still living when windthrown.

Fig. 2. Windthrown white pine that fell across a picnic table. Over 40 white pines were windthrown in this recreation area (in 1969). Rocky Bluff, Hot Springs Ranger District, Pisgah, National Forest - National Forests in North Carolina. (Photo: Courtesy of Jim Lunsford, Ranger, Hot Springs Ranger District.)

Fig. 3. White pine displaying the "thin crown" symptom associated with *F. annosus* infection. As shown, this symptom involves more defoliation and shortening of needles than discoloration of the infected host's crown.

F. annosus sign and symptom expression observed on the study plots suggested the probability of considerable root and butt rot in the residual living trees. Basal dissection of several infected trees in the Busick Plantation revealed well-developed butt-rot decay patterns (Fig.4). There is also evidence that at least a portion of this damage has resulted from other root and butt-rot causing fungi such as *Polyporous schweinitzii* L. (Fig. 5). Sporophores of *P. schweinitzii* (Fig. 6) were found on single trees on three plots and and increment core samples taken from living trees on the plot in the Pedlar River Plantation during the fall of 1966 revealed 20 percent *P. schweinitzii* infection. There was no evidence of either *P. schweinitzii* sporophore production or symptom expression in this stand. Hepting and Downs (1944) reported 75 percent root and butt-rot in a thinned white pine plantation at Biltmore. The majority of the rot was caused by *F. annosus* with a small percentage caused by *P. schweinitzii* and *P. circinatus*.

In conclusion, *F. annosus* has caused significant but erratic mortality patterns in five white pine plantations and one natural stand in western North Carolina during the past six years. Mortality and higher volume losses are still occurring in a 43-year-old plantation and a 66-year-old natural stand that were first thinned 20 or more years ago. However, a couple of points should be remembered in interpreting these results. First, as previously stated, the mortality was measured on established infection centers which usually make up only a fraction of the total stand area. Secondly, the majority of the trees killed during this study period were either suppressed or intermediate in crown class (68 percent-primarily in the younger plantations thinned between 1957 and 1959) which substantially reduced the volume loss. Both of these factors significantly reduce the overall stand mortality impact. However, as mortality continues to occur to larger trees in older stands, it significantly increases volume losses and damage impacts.

There is no ready explanation for the absence and comparatively small amount of mortality observed during the past six years in the Pedlar River and North River plantations, respectively, in western Virginia. There is no apparent correlation with such factors as stand condition, site characteristics, thinning history, former land use, topography, and soil conditions as these factors are all fairly similar in the Virginia and North Carolina plantations.

The numerous widespread reported occurrences of *F. annosus* infection and mortality in thinned white pine plantations along with the mortality and suggested continuous threat of repeated long-range losses (particularly windthrow) observed during this study suggest the necessity of protective stump treatment applications during thinning operations, particularly <u>first thinnings</u>, in white pine plantations in the Southern Appalachians. The most practical, safest and effective treatment presently available is dry borax applied to the exposed stump top <u>immediately</u> following cutting.

Fig. 4. *F. annosus* butt rot infection pattern in basal cross-section of white pine. Note how the rot is confined to and forms a continuous circle around the xylem tissue of the host. This is a soft spongy white rot and infected roots usually have a "stringy" spongy appearance.

Fig. 5. *P. schweinitzii* decay pattern in dissected white pine stem section. Note the contrast between this decay pattern and the *F. annosus* butt rot pattern in Fig. 4. *P. schweinitzii* causes a brown cubical rot that is dry and crumbly. This *P. schweinitzii* rot pattern extended up into the stem four feet above the ground.

Fig. 6. *P. schweinitzii* sporophore growing from root of white pine. Note the color, shape, and location of this sporophore on the host as compared with the *F. annosus* sporophore on the cover. (This sporophore was approximately ten inches in diameter.)

The results obtained from the one natural stand also suggest the necessity for consideration of similar protective stump treatments in high-value natural white pine stands.

Particular consideration should be given to any cutting of white pine in recreation or other high-value areas. Every effort should be made to prevent any invasion of *F. annosus* into these areas by treating, insofar as possible, all cut stumps and wounds occurring on living trees. Once root rot gets into these areas there is no known practical way of eradicating it. As previously pointed out, the resulting losses, expenses, and hazards can be high and probably will persist for several years.

The probability of significant root and butt-rot in living residual white pines suggested by these study results points out the desirability for additional followup field and laboratory studies. All the living trees on selected plots should be felled and the butt sections dissected to permit detailed observations and analysis of butt-rot occurrence. Tissue samples should be collected from representative rot decay margins to permit laboratory cultural diagnosis of the specific fungal causal agents.

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FIELD OFFICES	FOR STATES OF
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AREA OFFICE

Russel K. Smith
Assistant Area Director
Division of Forest Pest Control
Suite 800
1720 Peachtree Road, N.W.
Atlanta, Georgia 30309

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